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Using optimisation to identify the "best way" to trigger flow transition

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Understanding how fluids break down to turbulence has proved a fascinating and enduringly-difficult problem in fluid mechanics. Wall-bounded shear flows such as pipe flow, plane Couette flow and channel flow are particularly interesting as the observed transition depends on the environment and typically occurs abruptly leading immediately to complicated spatiotemporal flows. Theoretical efforts to gain understanding since the 1990s have either mostly focussed on a small-amplitude perspective of analysing the appropriate linear operator (modal and non-modal analysis) or taken a fully nonlinear perspective of calculating exact solutions of the equations and studying how their stable and unstable manifolds structure phase space (a dynamical systems approach). I will discuss how this conceptual gap (in amplitude) can be bridged using an optimisation approach which can be used to probe the nonlinear stability of a flow state. If the alternative state is turbulence, this approach identifies the optimal disturbance the *minimal seed* - to trigger transition. The essential ideas will be illustrated in a simple 2-degree-of-freedom model system before results for the Navier-Stokes equations and pipe flow will be presented together with some future perspectives. (Joint work with C. Caulfield, C. Pringle, S. Rabin & A. Willis)